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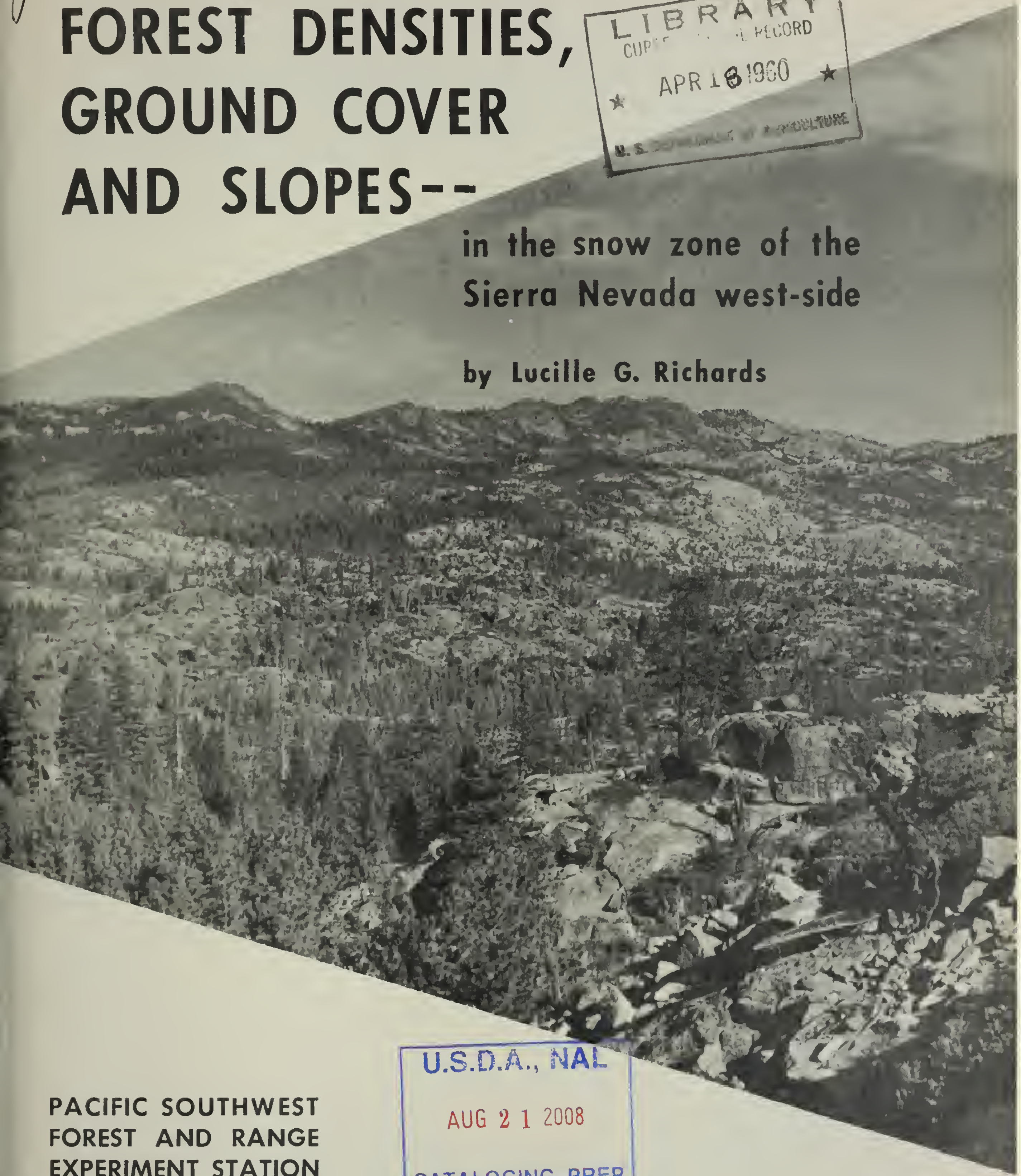
FOREST DENSITIES, GROUND COVER AND SLOPES--

in the snow zone of the Sierra Nevada west-side

by Lucille G. Richards



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FOREST AND RANGE
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FOREST DENSITIES, OPENINGS, GROUND COVER, AND SLOPES IN THE SNOW ZONE OF THE SIERRA NEVADA WEST-SIDE

By Lucille G. Richards, Research Forester
Division of Watershed Management Research

Technical Paper No. 40
October 1959

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE
PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION

SUMMARY

An aerial-photo survey showed that a large part of the west-side Sierra Nevada is open area, even at elevations of 5,000 to 8,000 feet above sea level. Much of this open area is covered by brush, and land managers will need to consider the management of brush as well as forest areas in their planning for future land use. Indeed, the range and distribution of cover and topographic conditions in the snow zone emphasize that planners will need to prepare for a wide variety of management problems.

COOPERATION

The study reported here was conducted in cooperation with

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

CONTENTS

Page

INTRODUCTION 1

METHODS USED IN MAKING THE INVENTORY 3

HIGHLIGHTS OF THE INVENTORY 6

DETAILS

Table 1.--Forest and slope characteristics 11

Table 2.--Percent distribution of forested and open area 12

Table 3.--Percent distribution of forest density 12

Table 4.--Percent distribution of openings 13

Table 5.--Percent distribution of cover in openings . . . 14

Table 6.--Percent distribution of slope gradient 15

Table 7.--Percent distribution of slope azimuth 15

Table 8.--Percent distribution of forested and open area by elevation 16

Table 9.--Percent distribution of forest density by elevation 17

Table 10.--Percent distribution of openings by size class and elevation 18

Table 11.--Percent distribution of openings by character of cover and elevation 19

Table 12.--Percent distribution of slope gradient by elevation 20

Table 13.--Percent distribution of slope azimuth by elevation 21

FOREST DENSITIES, OPENINGS, GROUND COVER, AND SLOPES IN THE SNOW ZONE OF THE SIERRA NEVADA WEST-SIDE

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INTRODUCTION

The snow zone in California covers about 12 million acres and produces half of the State's total streamflow. Most of the snow zone is on the west side of the Sierra Nevada and Cascade Range: from about 5,000 feet above sea level in the southern Sierra to 3,500 feet above sea level in the northern Sierra.[1]

The zone is divided into five distinct regions:[2]

Northwestern:	Basins of Klamath, Trinity, Mad, Eel, and adjacent rivers.
Northern:	Basin of Sacramento River above Shasta Dam, and of its western tributaries.
Central:	Western slope of Sierra Nevada, from Lassen Peak to Tehachapi Pass.
Eastern:	Eastern slope of Sierra Nevada: basins of Truckee, Mono and Owens Rivers.
Southern:	San Bernardino and other southern California mountains.

This study, part of a research program seeking improved water yield from the snow zone, was started in the Central Region, the largest of the five.

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[1] E. A. Colman, "Operation Wet Blanket," 17th Pacific Southwest Regional Meeting of the American Geophysical Union, Berkeley, California. February 5, 1955. Processed.

[2] H. W. Anderson and Arnold Court, Study Plan for an Inventory of Sierra Hydrologic Characteristics, Pacific Southwest Forest and Range Experiment Station, Berkeley, California, 1956.

One of the first steps was to find out just what kind of area we were dealing with. How much of the area is forested? How dense are the forest stands? How much of the area is bare ground? Covered with brush? How steep are the slopes? How does the vegetative cover vary with elevation? These were just a few of the questions needing answers to help orient the snow research program. The answers were obtained from an intensive study of topographic maps and aerial photographs.

This report summarizes the results for the area above 5,000 feet on the west side of the Sierra Nevada between the latitudes of 35°57-1/2' N. and 39°57-1/2' N. (fig. 1). The information is being used to help design experiments in snow physics and forest hydrology, and also to select watersheds for analysis. The results will also serve to inform California's land-use planners of the extent and location of various land conditions which may be subject to management in the future.

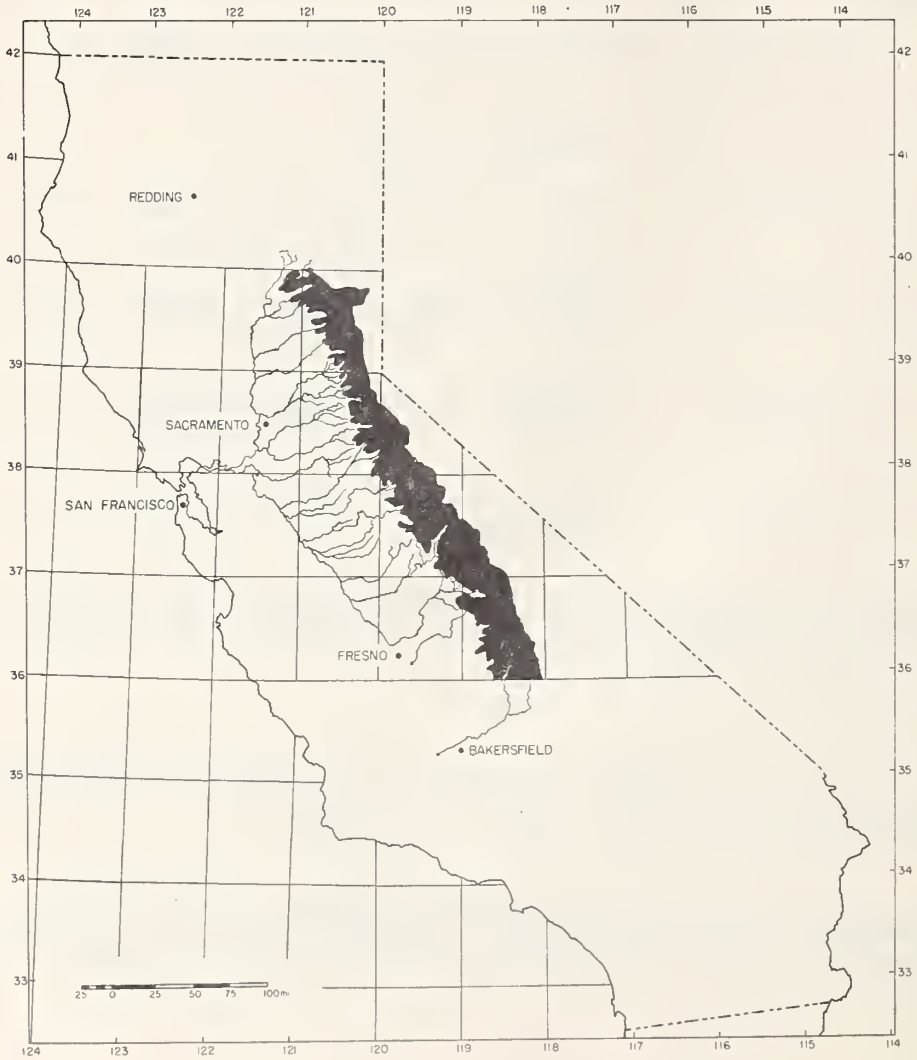


Figure 1.--Area included in inventory.

METHODS USED IN MAKING THE INVENTORY

Sample points were selected at the intersection of every 5 minutes of latitude and longitude on a grid extending the length of the Sierra Nevada, from 36°00' N. in the south to 39°55' N. in the north, and from the 5,000-foot contour interval in the west to the crest of the Sierra Nevada on the east (fig. 1). Detailed topographic, vegetation, and land-use characteristics of 40-acre sample tracts having their southeast corners at these latitude and longitude intersections were determined from U. S. Geological Survey maps, U. S. Army maps, and aerial photographs.

Topography and Drainage

For each tract the following information was obtained from topographic maps:

a. Elevation above sea level of the center of the tract to the nearest 10 feet.

b. Slope perpendicular to contour lines, in feet per 100 feet change in elevation.

c. Slope direction, as azimuth to the nearest 10 degrees downward through the center point.

d. Drainage, by name of minor stream and major basin.

Forests and Openings

The 40-acre tracts were then located on stereo-pairs of aerial photos, and ground cover characteristics were studied. Cover was classified into (1) forested, or (2) non-forested or open areas. The forested areas were sub-divided into density groups, and the open areas were classified by size and ground cover. Areas having a tree-crown density of 15 percent or more were considered forested; those with a tree-crown density of under 15 percent were classed as open.

Openings were measured and classified into the following size groups by their diameters:

Size Class:	Diameter in feet	Diameter in chains
I	Less than 132	Less than 2
II	132 - 263	2 - 4
III	264 - 527	4 - 8
IV	528 - 1,056	8 -16
V	Greater than 1,056	Greater than 16

The diameter of an opening was considered to be the diameter of the largest circle that could be inscribed within the opening. In determining the size class, the diameter was that for the entire opening including any part which fell outside the sample tract; however, the area measured was only the portion within the 40-acre tract. Openings of Size Class I were not measured individually except for roads and streams, but the areas were determined collectively from the crown density of the forested areas in which the openings occurred. In openings in Size Classes II to V, the acreages of the following cover types were determined: brush, grass-herb, crops, rock, talus, roads, buildings, streams, lakes and swamps.

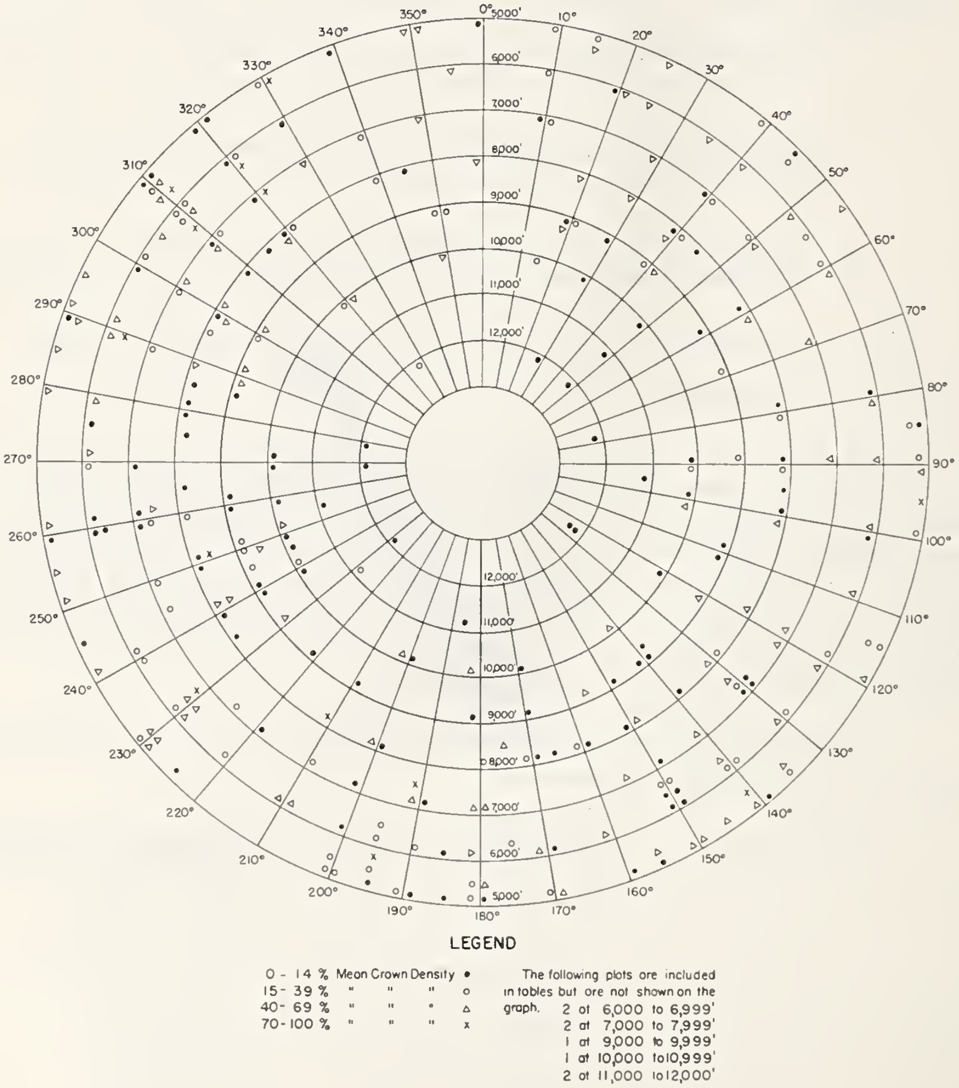
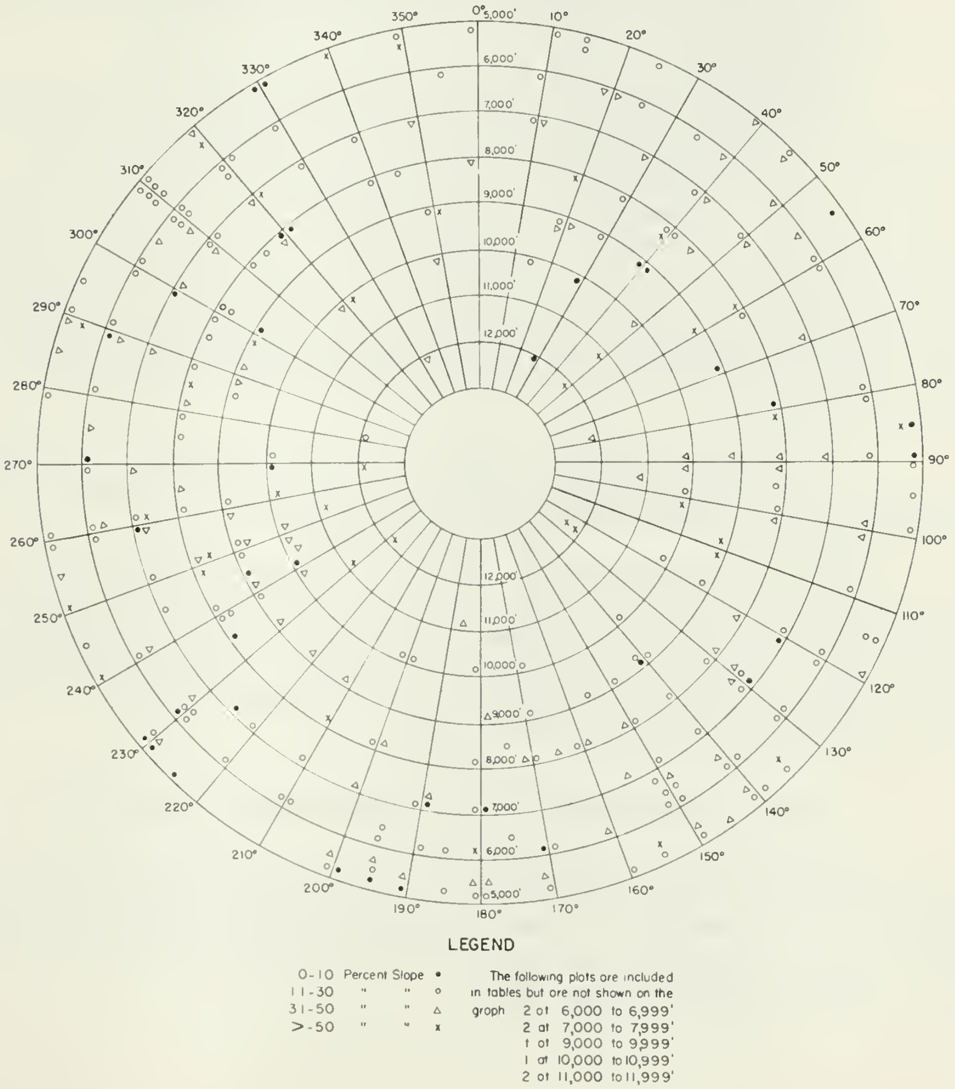


Figure 2.--Distribution of 40-acre plots by mean crown density, slope aspect, and elevation for the Sierra West-Side.

Forest densities were determined by subdividing the areas into classes of 15-39 percent, 40-69 percent, and 70-100 percent tree crown cover. Only trees 15 feet and over in height were considered in the forest density determinations, and no crown-cover class was recorded for the sampling tract unless it covered at least 4 acres, that is 10 percent, in the 40-acre sample.

The sample consisted of 331 tracts, or a total of 13,240 acres. The data were first summarized by 4 latitudinal groups, 1 degree in length, and then by elevational zones. To aid in visualizing the data, they were plotted on two graphs showing different combinations of forest density classes, elevations, slope aspects, or slope gradients (figs. 2 and 3).



The following plots are included in tables but are not shown on the graph
2 at 6,000 to 6,999'
2 at 7,000 to 7,999'
1 at 9,000 to 9,999'
1 at 10,000 to 10,999'
2 at 11,000 to 11,999'

Figure 3.--Distribution of 40-acre plots by slope gradient, slope aspect, and elevation for the Sierra West-Side.

HIGHLIGHTS OF THE INVENTORY

1. The western slope of the Sierra Nevada snow zone is not an area of continuous forests.

Though many people think otherwise, only 42 percent of the west-side Sierra snow zone is forested, that is, has a tree canopy cover greater than 15 percent; the other 58 percent of the Sierra is open (fig. 4). Almost one-half of this open area is rock or bare ground and about a third is covered by brush. The remainder of the open area consists of low-lying grass and herbs, roads, lakes, and other miscellaneous types of cover (table 1). For the most part, slopes are not steep; more than 60 percent have slope gradients of less than 30 percent (table 1).

2. The south Sierra has more forested area; the north more dense forests.

The southern part of the Sierra Nevada, which includes the watersheds of the northern part of the Kern River, Kaweah River, and South Fork of the Kings River, has 9 to 13 percent more forested area than the rest of the Sierra Nevada (table 2). The northern part, containing the watersheds of the Feather, Yuba, and Bear Rivers, has more forests in the 70-100 percent density class (table 3). Brush cover increases progressively from south to north (table 5). The area along the watersheds of the San Joaquin and Merced rivers has the highest percentage of open area (table 4), and also the highest percentage of rock and bare ground (table 5).

3. Lower elevations in the snow zone, though more forested than the high country, have much open ground.

Only about one-half of the area between 5,000 feet and 8,000 feet is in forests. The amount of open area increases with elevation (table 8) in the snow zone, and so does the amount of bare ground. However, the amount of brush in the open area decreases with elevation, and above 12,000 feet less than 1 percent of the open area has brush cover (table 11).

4. Dense forests are most frequent at low elevations.

Forests with a density of more than 70 percent decrease as the elevation increases except for a few remnants above 12,000 feet (table 9). The amount of area in large openings increases progressively with elevation. Above 12,000 feet 89 percent of the area is in large openings (table 10).

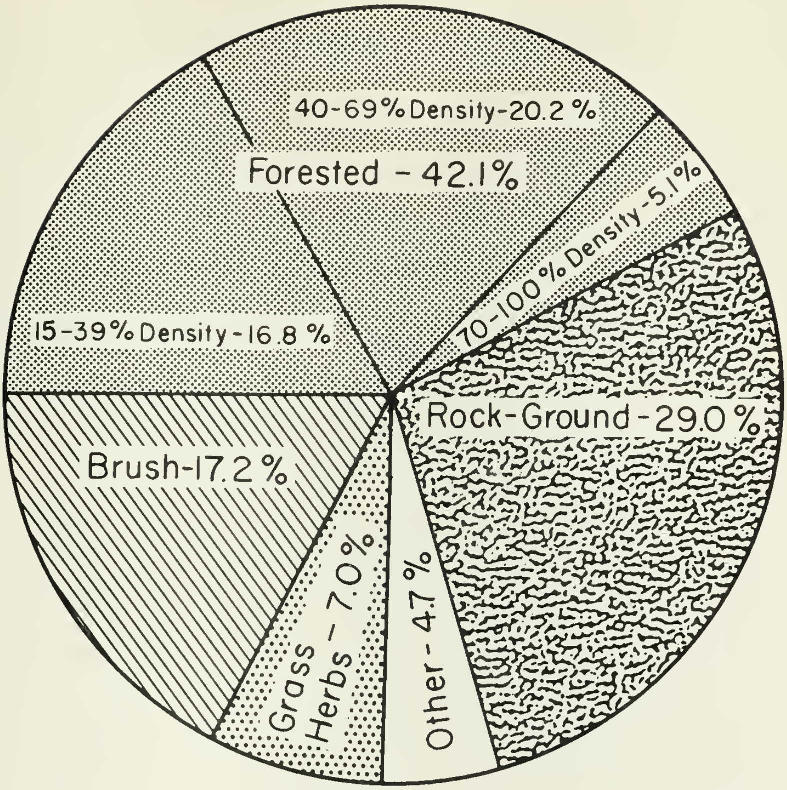


Figure 4.--Distribution of ground cover on the west side of the Sierra Nevada above 5,000 feet elevation between the Latitudes 35°57-1/2' and 39°57-1/2'.

APPENDIX

Table 1.--Forest and slope characteristics for elevations above 5,000 feet on the west side of the Sierra Nevada, Latitudes 35°57-1/2' N. to 39°57-1/2' N.

Item	Acreage sampled	Percent of area
FOREST OPENINGS		
Less than 132 feet across[1]	2,978.9	22.5
Less than 132 feet across[2]	11.8	.1
132-263 feet across	131.6	1.0
264-527 feet across	377.5	2.9
528-1,056 feet across	728.8	5.5
>1,056 feet across	6,412.5	48.3
Total	10,641.1	[3]80.3
FOREST DENSITY		
0-14 percent	7,662.2	57.9
15-39 percent	2,220.6	16.8
40-69 percent	2,681.7	20.2
70-100 percent	675.5	5.1
Total	13,240.0	100.0
CONDITIONS IN OPENINGS[4]		
Grass-Herb	928.3	12.1
Brush	2,271.4	29.6
Trees	344.7	4.5
Crops	14.3	.2
Rock-Ground	3,628.1	47.4
Talus	206.6	2.7
Roads	24.1	.3
Buildings	1.8	.2
Streams	17.8	
Lakes	181.2	2.4
Swamps	43.9	.6
Total	7,662.2	100.0
SLOPE		
0-10 percent	-	13.3
11-20 percent	-	29.0
21-30 percent	-	18.7
31-40 percent	-	20.3
41-50 percent	-	7.9
51-60 percent	-	4.2
61-70 percent	-	2.7
over 71 percent	-	3.9
Total	-	100.0
SLOPE DIRECTION		
North	-	19.0
East	-	20.3
South	-	26.0
West	-	32.3
Level	-	2.4
Total	-	100.0

[1] Collectively determined.

[2] Individually measured openings consisted of roads and streams.

[3] Percent of total area.

[4] Openings greater than 132 feet across.

Table 2.--Percent distribution of forested and open area by latitude

Latitude	Forested area	Open area
36°00' to 36°55' N.	50.3	49.7
37°00' to 37°55' N.	36.8	63.2
38°00' to 38°55' N.	40.8	59.2
39°00' to 39°55' N.	41.0	59.0
Average	42.1	57.9

Table 3.--Percent distribution of forest density by latitude

Density class	36°00' to 36°55' N.	37°00' to 37°55' N.	38°00' to 38°55' N.	39°00' to 39°55' N.	Average
0-14 % Cover	49.7	63.2	59.2	59.0	57.9
15-39 % "	14.2	15.2	21.1	17.2	16.8
40-69 % "	31.1	18.3	15.4	15.3	20.2
70-100% "	5.0	3.3	4.3	8.5	5.1
Total	100.0	100.0	100.0	100.0	100.0

Table 4.--Percent distribution of openings by size class and latitude

Size class	36°00' to 36°55' N.	37°00' to 37°55' N.	38°00' to 38°55' N.	39°00' to 39°55' N.	Average
Less than 132 feet across[1]	25.0	20.6	22.7	22.0	22.5
Less than 132 feet across[2]	0.1	0.1	0	0.2	0.1
132-263 feet across	0.5	0.9	0.7	2.0	1.0
264-527 feet across	1.9	3.0	2.8	3.8	2.9
528-1,056 feet across	4.6	5.2	5.7	6.8	5.5
Greater than 1,056 feet across	42.6	54.0	49.9	46.2	48.3
Total[3]	74.7	83.8	81.8	81.0	80.3

[1] Collectively determined.

[2] Individually measured openings consisted of roads and streams.

[3] Percent of total area.

Table 5.--Percent distribution of cover in openings by latitude

Conditions in openings[1]	36°00' to 36°55' N.	37°00' to 37°55' N.	38°00' to 38°55' N.	39°00' to 39°55' N.	Average
Grass-Herb	10.4	8.8	10.5	20.3	12.1
Brush	21.5	22.1	31.9	46.1	29.6
Trees	5.5	4.8	3.9	3.7	4.5
Crops	0	0	0	0.8	0.2
Rock-Ground	52.4	55.6	52.8	24.6	47.4
Talus	5.0	4.9	0	0.1	2.7
Roads	0.3	0.2	0.3	0.6	0.3
Buildings	0	0	0	0.1	0.2
Streams	0.4	0.1	0.4	0.1	
Lakes	3.9	3.1	0	2.3	2.4
Swamps	0.6	0.4	0.2	1.3	0.6
Total	100.0	100.0	100.0	100.0	100.0

[1] Openings greater than 132 feet across.

Table 6.--Percent distribution of slope gradient by latitude

Slope gradient	36°00' to 36°55' N.	37°00' to 37°55' N.	38°00' to 38°55' N.	39°00' to 39°55' N.	Average
0-10 percent	10.6	17.5	14.3	9.7	13.3
11-20 percent	15.3	29.9	41.5	30.5	29.0
21-30 percent	16.5	14.4	22.1	23.6	18.7
31-40 percent	30.6	18.6	7.8	23.6	20.3
41-50 percent	8.2	11.3	5.2	5.6	7.9
51-60 percent	9.4	1.0	5.2	1.4	4.2
61-70 percent	2.3	2.1	2.6	4.2	2.7
Over 71 percent	7.1	5.2	1.3	1.4	3.9
Total	100.0	100.0	100.0	100.0	100.0

Table 7.--Percent distribution of slope azimuth by latitude

Azimuth	36°00' to 36°55' N.	37°00' to 37°55' N.	38°00' to 38°55' N.	39°00' to 39°55' N.	Average
North 316° - 45°	23.5	16.5	18.2	18.1	19.0
East 46° - 135°	29.4	20.6	11.7	18.1	20.3
South 136° - 225°	14.1	27.9	29.9	33.3	26.0
West 226° - 315°	29.4	30.9	40.2	29.1	32.3
Level	3.6	4.1	0	1.4	2.4
Total	100.0	100.0	100.0	100.0	100.0

Table 8.--Percent distribution of forested and open area by elevation above sea level

Elevation, feet M.S.L.	Forested	Open
5,000- 5,999	53.0	47.0
6,000- 6,999	50.4	49.6
7,000- 7,999	42.5	57.5
8,000- 8,999	35.7	64.3
9,000- 9,999	32.5	67.5
10,000-10,999	34.5	65.5
11,000-11,999	11.4	88.6
Over 12,000	9.4	90.6
Average	42.1	57.9

Table 9.--Percent distribution of forest density by elevation above sea level

Elevation, feet M.S.L.	Density class				Total
	0-14 Percent cover	15-39 Percent cover	40-69 Percent cover	70-100 Percent cover	
5,000- 5,999	47.0	21.5	20.6	10.9	100.0
6,000- 6,999	49.6	20.5	24.4	5.5	100.0
7,000- 7,999	57.5	13.4	26.1	3.0	100.0
8,000- 8,999	64.3	13.3	18.0	4.4	100.0
9,000- 9,999	67.5	17.7	13.4	1.4	100.0
10,000-10,999	65.5	12.5	22.0	0	100.0
11,000-11,999	88.6	11.4	0	0	100.0
Over 12,000	90.6	0	6.3	3.1	100.0
Average	57.9	16.8	20.2	5.1	100.0

Table 10.--Percent distribution of openings by size class and elevation above sea level

Size class	5,000 ft. to 5,999 ft.	6,000 ft. to 6,999 ft.	7,000 ft. to 7,999 ft.	8,000 ft. to 8,999 ft.	9,000 ft. to 9,999 ft.	10,000 ft. to 10,999 ft.	11,000 ft. to 11,999 ft.	Over 12,000 ft.	Average
< 132 ft. across[1]	27.8	26.5	22.2	18.9	19.2	19.8	7.4	4.4	22.5
< 132 ft. across[2]	0.1	0.2	0.2	0	0	0	0	0	0.1
132-263 ft. across	1.4	1.4	1.3	0.5	0.8	0	0	0.3	1.0
264-527 ft. across	2.4	5.4	2.6	2.2	1.8	1.6	0	1.4	2.9
528-1,056 ft. across	4.4	7.6	8.8	3.5	7.1	2.0	0	0	5.5
> 1,056 ft. across	38.7	35.0	44.6	58.1	57.8	61.9	88.6	88.9	48.3
Total[3]	74.8	76.1	79.7	83.2	86.7	85.3	96.0	95.0	80.3

[1] Collectively determined.

[2] Individually measured openings consisted of roads and streams.

[3] Percent of total area.

Table 11.--Percent distribution of openings by character of cover and elevation above sea level

Conditions in openings[1/]	5,000 ft. to 5,999 ft.	6,000 ft. to 6,999 ft.	7,000 ft. to 7,999 ft.	8,000 ft. to 8,999 ft.	9,000 ft. to 9,999 ft.	10,000 ft. to 10,999 ft.	11,000 ft. to 11,999 ft.	Over 12,000 ft.	Average
Grass-Herb	16.3	12.4	14.8	9.2	13.0	10.0	5.7	3.3	12.1
Brush	52.5	40.7	32.7	23.5	15.0	13.0	2.1	0.6	29.6
Trees	3.9	5.5	4.2	6.0	4.4	4.4	0.6	0.4	4.5
Crops	1.0	0	0	0	0	0	0	0	0.2
Rock-Ground	25.2	36.1	45.1	58.4	60.7	62.7	68.1	61.6	47.4
Talus	0	0	0.3	1.6	2.8	4.1	5.8	33.3	2.7
Roads	0.7	0.7	0.4	0	0	0	0	0	0.3
Buildings	0.1	0	0	0	0	0	0	0	0.2
Streams	0.3	0	0.4	0.3	0.3	0.3	0	0	
Lakes	0	2.6	2.1	0.1	3.5	5.5	17.7	0.8	2.4
Swamps	0	2.0	0	0.9	0.3	0	0	0	0.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1/] Openings greater than 132 feet across.

Table 12.--Percent distribution of slope gradient by elevation above sea level

Slope gradient	5,000 ft. to 5,999 ft.	6,000 ft. to 6,999 ft.	7,000 ft. to 7,999 ft.	8,000 ft. to 8,999 ft.	9,000 ft. to 9,999 ft.	10,000 ft. to 10,999 ft.	11,000 ft. to 11,999 ft.	Over 12,000 ft.	Average
0-10 percent	14.9	8.2	18.7	7.0	18.4	16.0	28.6	11.1	13.3
11-20 percent	28.4	43.8	29.2	26.3	23.7	16.0	0	11.1	29.0
21-30 percent	21.6	23.3	10.4	24.6	13.1	20.0	0	0	18.7
31-40 percent	18.9	17.8	22.9	17.5	26.3	28.0	14.3	11.1	20.3
41-50 percent	4.0	5.5	14.6	10.5	5.3	8.0	14.3	11.1	7.9
51-60 percent	6.8	0	2.1	5.3	5.3	8.0	0	11.1	4.2
61-70 percent	2.7	1.4	0	5.3	2.6	4.0	14.2	0	2.7
Over 71 percent	2.7	0	2.1	3.5	5.3	0	28.6	44.5	3.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 13.--Percent distribution of slope azimuth by elevation above sea level

Azimuth	5,000 ft. to 5,999 ft.	6,000 ft. to 6,999 ft.	7,000 ft. to 7,999 ft.	8,000 ft. to 8,999 ft.	9,000 ft. to 9,999 ft.	10,000 ft. to 10,999 ft.	11,000 ft. to 11,999 ft.	Over 12,000 ft.	Average
North 316°- 45°	20.3	15.1	20.8	21.1	21.1	20.0	28.6	22.2	19.0
East 46°-135°	16.2	19.2	22.9	21.1	15.8	24.0	0	44.5	20.3
South 136°-225°	33.8	28.8	25.0	22.8	23.7	20.0	28.6	0	26.0
West 226°-315°	29.7	34.2	27.1	35.0	36.8	32.0	14.2	33.3	32.3
Level	0	2.7	4.2	0	2.6	4.0	28.6	0	2.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0